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Research Notes : Screening for immature green soybeans as a vegetable

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1) Relationship between photoperiod, temperature, solar radiation and grain yield in soybean

Photoperiod and temperature influence the growth, development and area of adaptation of soybean cultivars (Shanmugasundaram, 1981). Germplasm collected from the U.S. Maturity Groups 00 to X were screened for photoperiodic response and were classified into 10 different photoperiod sensitivity score groups, based on flowering in 10 and 16 hr photoperiods (Shanmugasundaram, 1981). By utilizing 0 sensitivity score types as one parent, high yielding selections with different levels of photoperiod sensitivity have been developed.

A total of 61 and 39 selections in 1980 and 1981, respectively, was evaluated for yield in spring, summer and autumn in advanced yield trials.

Using the natural day length and controlled light rooms either to extend day length or to provide darkness, days-to-flowering were determined for each selection in 10, 12, 14 and 16 hr photoperiods. The deviation in days-to-flowering between 10 and 16 hr (A), 10 and 14 hr (B), 10 and 12 hr (C), 12 and 14 hr (D), 14 and 16 hr (E) and 12 and 16 hr (F) were determined and a photoperiod sensitivity score was assigned to each selection for each of the above categories A to F.

The degree-day was computed for each selection by summing the mean daily temperature above 15°C from sowing to maturity of each selection (Nuttonson, 1957). Similarly, solar radiation required from sowing to maturity for each selection was determined by summing the daily solar radiation from sowing to maturity. Simple correlation coefficients between grain yield, photoperiod sensitivity scores, the degree-day and the solar radiation were determined.

Two years' results suggest that the relationship between grain yield and the other environmental variables varied with the season. None of the variables had any influence on grain yield in the autumn season. During the summer season, however, low photoperiod scores (i.e., insensitive selections) were correlated with higher yields and vice versa. Results from the spring season suggest that sensitivity to photoperiod is desirable to obtain high yield (Table 1). Similarly, there was a negative correlation between degree-day and solar radiation and high yield for the summer season, only suggesting that higher degree-days or solar radiation lowers yield and vice versa (Table 2). No significant relationship between degree-day and yield was evident during the spring or autumn seasons. However, yield was positively correlated with solar radiation during the spring season (Table 2).

Our results suggest the advisability of selecting photoperiod insensitive lines with high yield potential at least for latitude 23°N to successfully produce high yielding selections in the summer season. During early spring and late autumn the temperatures at our location are much lower than during other times. We speculate that either the temperature or the photoperiod X temperature interaction during spring and autumn exert more influence on yield than does photoperiod alone. Therefore, temperature response of the photoperiod insensitive selections need to be investigated.

Table 1. Simple correlation coefficient between yield and photoperiod sensitivity score in three seasons during 1980 and 1981

Season	Year	Photoperiod sensitivity score A 10-16 hr	B 10-14 hr	C 10-12 hr	D 12-14 hr	E 14-16 hr	F 12-16 hr
Spring	1980	0.34**	0.38**	0.36**	0.45**	NS[a]	0.43**
	1981	0.37*	NS	NS	NS	NS	0.44**
Summer	1980	-0.54**	-0.45*	-0.27**	-0.45**	-0.55**	-0.53**
	1981	-0.33**	NS	-0.36**	-0.33*	-0.34*	-0.35*
Autumn	1980	NS	NS	NS	NS	NS	NS
	1981	NS	NS	NS	NS	NS	NS

[a]NS = Not Significant

*Significant at the 5% level.

**Significant at the 1% level.

Table 2. Simple correlation coefficient between high yields and either degree-day or solar radiation in three seasons during 1981

Variable	Yield Spring	Summer	Autumn
Degree-day	0.30 NS[a]	-0.32*	0.06 NS
Solar radiation	0.32*	-0.33*	0.07 NS

[a]NS = Not Significant.

*Significant at the 5% level.

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2) <u>Screening for immature green soybeans as a vegetable</u>

Soybeans, either immature green beans in pod as in Japan, or shelled immature green beans as in China, are used as a vegetable in a number of countries. Although there is no strict definition for vegetable soybeans, generally large pods and seeds are preferred. The pubescence and hilum color should be gray. Majority of the pods should be either 2 or 3 seeded. The immature green beans cook easily and have mild nutty flavor (Kline, 1980). Countries like Japan have rigid taste and flavor requirements.

We evaluated 136 large-seeded germplasm accessions against two locally grown vegetable soybeans. The experiment was planted in the field on July 2, 1981, in a randomized complete block design with two replications.

The results suggest that the germplasm has both earlier and later flowering and maturing types than the checks. One-hundred-seed weight ranged from 12 to 45 gms with a mean of 24 gm on 13% moisture basis. Percent of pods with two or more seeds ranged from 42 to 100 with a mean of 89% (Table 1).

Among the 136 entries, 63 had gray pubescence, with yellow or light-green seed coat. However, only three accessions had both gray pubescence and 100-seed weight of 30 gm or more, comparable to the check 'Tzurunoku' (Table 2).

The length and width of pods were measured at R_6 stage (Fehr and Caviness, 1977) and were related to the 100-seed weight. Our results show that even among the germplasm, pod width and pod length are highly significantly associated with 100-seed weight ($r = 0.66^{**}$ for both pod length and pod width with 100-seed weight of 2-seeded pods and $r = 0.63^{**}$ for 3-seeded pods). Frank and Fehr (1981) reported that pod length and pod width were significantly associated with 100-seed weight and can be used as an indirect selection criteria for 100-seed weight.

Sample seeds of the four large-seeded soybeans (Table 3) will be available for trials.

Table 1. Variability for time to flowering and time to maturity of 136 large-seeded soybeans compared with two local vegetable types

	Days to			100-seed wt (g)[b]	% 2-seeded pods
	R_1 [a]	R_6	R_8		
For 136 germplasm					
Range	20–47	56–113	71–129	12–45	42–100
Mean	33	81	95	24	89
CV %	16	12	10	24	8
Tzurunoku (CK)	33	83		30	95
Zen Wu #2 (CK)	26	75		12	90

[a] Fehr and Caviness (1977). [b] On 13% moisture basis.

Table 2. Classification 136 large-seeded soybeans based on seed coat color, pubescence color and 100-seed weight

Seed coat color	With acceptable pubescence[b] <19.9	20.0–29.9	>30.0	With tawny pubescence <19.9	20.0–29.9	>30.0
Yellow and light green	10	50	3	11	28	4
Black	0	1	3	0	12	5
Brown	0	0	0	0	4	1
Mottled	0	0	0	1	3	0

100-seed weight[a] (g)

[a] On 13% moisture basis.

[b] Gray or light colored and sparse.

Table 3. Agronomic characters of 3 vegetable types with yellow or green seed coat and gray pubescence selected from 136 large-seeded germplasm

AVRDC No.	Name or PI number	100 seed wt[a] (g)	Days to R_1	Days to R_6	Days to R_8	cm: 2-seed pod L^b	cm: 2-seed pod W^b	cm: 3-seed pod L	cm: 3-seed pod W	% of 2 or more seeded pods
G 10134	Green light	34	34	83	92	5.1	1.4	5.8	1.3	73
G 7321	157424	33	35	82	106	4.7	1.3	5.5	1.3	99
G 10157	Chou Hou	31	33	80	100	5.0	1.2	5.9	1.3	92
G 9053	Tzurunoku (CK)	30	33	83	101	5.0	1.2	5.9	1.2	95

[a] On 13% moisture basis.

[b] L: Length, W: Width.

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3) Yield evaluation of immature, green soybeans

Soybeans are commonly called the "meat of the fields" in the orient. Soybean is a popular vegetable in oriental diet and is rich in vitamins A and B and is a good source of protein, fat, calcium, phosphorous and iron. Soybean as a vegetable can be grown easily even during the rainy season since the final product to be harvested is immature green seed.

At the Asian Vegetable Research and Development Center one of our objectives is to develop productive vegetable-type soybeans. We evaluated six selections and one accession (Acc.) and two local cultivars in the spring (planted Jan. 31, '81) and autumn seasons (planted Sep. 16, '81). The trial was conducted in a randomized complete block design with four replications.

In Taiwan the farmers are paid based on total plant weight, the middlemen are paid by the companies based on total amount of two- or more-seeded pods. The local market deals with shelled immature green beans. Therefore, data were collected on all the above parameters.

Our results showed that, regardless of the season, some of our breeding lines have the potential to produce a total biomass of 24 t/ha on fresh weight basis and up to 43% of which can be pods. Two- or more-seeded pods ranged from 71 to 92% in the spring and 84 to 92% in the autumn season (Table 1).

AGS 164 yielded 10.7 t/ha of green beans in 94 days in the spring season. Acc. G 8285 in the autumn season produced 17 t/ha green bean in 80 days which is 41% higher yield than the best check, Acc. G 9053. In addition, three of our new breeding lines outyielded the best check in greenbean yield in the spring planting (Table 2).

In an organoleptic test of the vegetable soybeans the desirable selections identified by the Chinese, Indians, Indonesians, Koreans, Filipinos and Americans were G 8285, G 9053, and G 9948. However, Americans and Koreans liked all the entries.

Sample seeds of any of the entries mentioned in this paper may be obtained by writing to the senior author.

Table 1. Total biomass production and their partitioning into component plant parts in vegetable soybeans[a]

AVRDC No.	Total plant wt. t/ha	Leaf	Stem	Pod	Percent of two- or more-seeded pods
Spring season:	Date planted - Jan. 31, 1981				
AGS 163	23 ab[b]	7.0 (30)[c]	7.5 (32)	8.7 (38)	86
AGS 164	22 ab	5.0 (23)	8.0 (36)	9.1 (41)	87
AGS 165	22 ab	6.7 (31)	6.8 (31)	8.2 (38)	87
AGS 166	23 ab	6.5 (28)	8.3 (36)	8.5 (36)	92
AGS 167	24 a	5.9 (24)	9.0 (37)	9.4 (39)	88
AGS 168	22 ab	5.1 (23)	7.7 (36)	8.8 (41)	89
G 8285	21 b	5.8 (28)	5.6 (27)	9.5 (45)	86
G 9053 (CK)	14 c	4.1 (30)	3.2 (24)	6.2 (46)	71
G 9948 (CK)	13 c	3.9 (29)	3.2 (24)	6.2 (47)	87
Autumn season:	Date planted - Sep. 16, 1981				
AGS 163	24 a	6.8 (28)	7.1 (29)	10.3 (43)	92
AGS 164	24 a	8.3 (35)	8.5 (35)	7.2 (30)	85
AGS 165	23 ab	7.5 (34)	6.6 (29)	8.4 (37)	89
AGS 166	23 ab	6.2 (27)	8.2 (35)	9.0 (38)	87
AGS 167	22 ab	5.6 (25)	7.7 (35)	9.0 (40)	86
AGS 168	21 b	5.1 (24)	7.7 (36)	8.5 (40)	84
G 8285	20 bc	4.3 (21)	6.3 (32)	9.3 (47)	84
G 9053 (CK)	23 ab	7.0 (30)	5.7 (25)	10.2 (45)	84
G 9948 (CK)	18 c	5.6 (31)	5.0 (28)	7.5 (41)	91

[a]Data are on fresh weight basis.

[b]Means followed by the same letters are not significantly different at 5% level as per DMRT.

[c]Values in parentheses are percent of total plant weight on fresh weight basis.

Table 2. Immature green-bean yield and selected agronomic characters of 7 vegetable soybean selections

AVRDC No.	Green bean yield[a] t/ha		Days to R_6		100-seed wt. at R_6	
	Spring	Autumn	Spring	Autumn	Spring	Autumn
AGS 163	7.8 bc[b]	10.8 b	90	73	31 e	39 de
AGS 164	10.7 a	7.6 b	94	73	41 cd	43 d
AGS 165	7.9 bc	7.3 b	90	66	40 cd	38 e
AGS 166	8.6 b	9.9 b	95	80	41 cd	47 c
AGS 167	9.1 ab	9.7 b	94	80	39 d	39 de
AGS 168	7.3 c	9.8 b	95	80	40 cd	39 de
G 8285	7.4 bc	17.0 a	90	80	51 ab	54 b
G 9053 (CK)	4.8 d	10.1 b	80	73	46 bc	56 b
G 9948 (CK)	6.1 cd	6.8 b	80	66	56 a	64 a

[a]Data are on 90% moisture basis.

[b]Means followed by the same letters are not significantly different at 5% level as per DMRT.

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4) Forcing soybeans to mature by spraying paraquat

In the tropics, soybeans theoretically can be grown year around. The rainfall pattern distinguishes the soybean crop as either wet season or dry season. Rainfall at harvest time invariably causes sprouting of the seeds in the field and can result in a total loss of the crop. However, if a crop can be grown successfully, a season can be saved in the breeding program. An experiment was conducted to artificially force maturity prior to seasonal rains at maturity.

Paraquat at 3.5 liters of ICI commercial product per hectare (0.84 liter a.i. of 1-1' Dimethyl 4, 4' bipyridylium dichloride) was sprayed at either R_6, $R_{6.5}$ or R_7 (Fehr and Caviness, 1977) versus natural maturity without any spray as a control. The experiment was conducted during the summer rainy season using three AVRDC soybean selections: AGS 2, AGS 17 and G 2261.

The results suggest that the soybean crop can be forced to mature by as much as two weeks earlier than normal (control) with paraquat spray at stage R_6 (Table 1). When paraquat was sprayed at R_6 or $R_{6.5}$, the 100-seed weight was reduced by 20 to 34% compared with the control (Table 2). There was a significant yield reduction in treatments with paraquat spray at stage R_6 and $R_{6.5}$ as compared with R_7 and control (Table 3).

Table 1. Days from sowing to maturity influenced by paraquat spray at different growth stages in three selections

AVRDC No.	Growth stage when paraquat was sprayed			Control	Mean[a]
	R_6	$R_{6.5}$	R_7		
AGS 2	106	106	114	121	112 a
AGS 17	98	98	102	102	100 b
G 2261	88	92	98	102	95 c
Mean[a]	97 d	98 c	104 b	108 a	

[a]Means followed by the same letter are not significantly different at the 5% level as per DMRT.

Table 2. Influence of paraquat spray on 100-seed weight (gm) in three selections

AVRDC No.	Growth stage when paraquat was sprayed			Control	Mean[a]
	R_6	$R_{6.5}$	R_7		
AGS 2	4.8	4.8	6.1	6.4	5.5 c
AGS 17	9.9	11.6	12.5	14.9	12.2 b
G 2261	12.3	12.4	14.7	15.4	13.7 a
Mean[a]	9.0 c	9.6 c	11.1 b	12.2 a	

[a]Means followed by the same letters are not significantly different at the 5% level as per DMRT.

Table 3. The grain yield (kg/ha) influenced by paraquat spray at different growth stages in three selections

AVRDC No.	Growth stage when paraquat was sprayed			Control	Mean[a]
	R_6	$R_{6.5}$	R_7		
AGS 2	1,350	1,384	2,108	2,211	1,764 a
AGS 17	895	1,324	1,516	1,860	1,399 ab
G 2261	991	938	1,282	1,333	1,137 b
Mean[a]	1,079 b	1,216 b	1,636 a	1,802 a	

[a]Means followed by the same letters are not significantly different at the 5% level as per DMRT.

Table 4. Percent germination of seeds harvested with and without paraquat spray in three cultivars

AVRDC No.	Growth stage when paraquat was sprayed			Control	Mean[a]
	R_6	$R_{6.5}$	R_7		
AGS 2	63 (92)[b]	56 (92)	64 (94)	62 (90)	61 a (92 a)
AGS 17	41 (80)	26 (50)	18 (87)	82 (96)	42 b (78 ab)
G 2261	43 (85)	37 (86)	17 (59)	26 (57)	31 b (72 ab)
Mean[a]	49 ab (86)[c]	40 ab (76)	33 b (80)	57 a (81)	

NOTE: There is significant interaction between selections used and the treatments.

[a]Means followed by the same letters are not significantly different at the 5% level as per DMRT.

[b]Open values are without captan seed treatment and values in parentheses are with captan seed treatment.

[c]With captan seed treatment differences were not significant.

The yield reduction of 33 to 40% in treatments of paraquat spray at R_6 and $R_{6.5}$ against the control appears to be due to the reduced seed size in the treated plots as opposed to a total loss if rains occur at maturity. However, under the present experimental conditions, the control had significantly higher yield than treatments due to their escape from rain.

Since viability of the harvested seed is important in breeding, a germination test was conducted. The paraquat spray treatments at stage R_6 and $R_{6.5}$ did not adversely affect germination compared with the untreated control (Table 4). However, there was significant interaction between selections used and the treatments. If the harvested seeds were treated with captan the percent of germination was markedly improved and there was no significant difference in percent of germination of the seeds in treated and control. Although preliminary results suggest that paraquat spray prior to maturity can hasten maturity and permit soybean production, the significant interaction between selections used and the paraquat spray treatments requires further evaluation before the paraquat spray can be recommended for use either for plant breeding or commercial soybean production in wet season.

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